DECLARATION OF TOMAS PALACIOS UNDER 37 C.F.R. § 1.132

I, TOMAS PALACIOS, declare as follows:

1. I am an Assistant Professor in the Department of Electrical Engineering and Computer Science of the Massachusetts Institute of Technology (MIT). I received a BS degree in Telecommunication Engineering from Polytechnic University of Madrid in 2001, and MS and PhD degrees in Electrical Engineering from the University of California - Santa Barbara in 2004 and 2006, respectively. My complete resume and curriculum vitae are available at http://web.mit.edu/tpalacios/index.html.

2. I am an author of a publication by T. Palacios, F. Calle, E. Monroy, F. Naranjo, M. A. Sánchez-García, E. Calleja and E. Muñoz, entitled "Wet Etching of GaN grown by molecular beam epitaxy on Si(111)," Semic. Sci. and Tech., 2000, vol. 15, pp. 996-1000.

3. My publication describes how pyramidal nanostructures are formed on the surface of an emitting layer by etching to increase the efficiency of the emitting layer. Specifically, my publication observed an increase in the photoluminescence (PL) intensity after forming the pyramids by etching. As written at that time, "[t]he energy shift and intensity enhancement can be explained by the relaxation of tensile strain during the formation of the pyramids, although a contribution from quantum confinement in the nanostructures cannot be discarded," at page 998, column 2. At the time I carried out these experiments, I did not make an association between the increase in the PL intensity and a higher light extraction efficiency.

4. The pyramidal nanostructures in my publication have a size (height or depth) of about 60 nm. This is shown in Figures 4 and 5, and the accompanying text, of my publication:

Figure 4

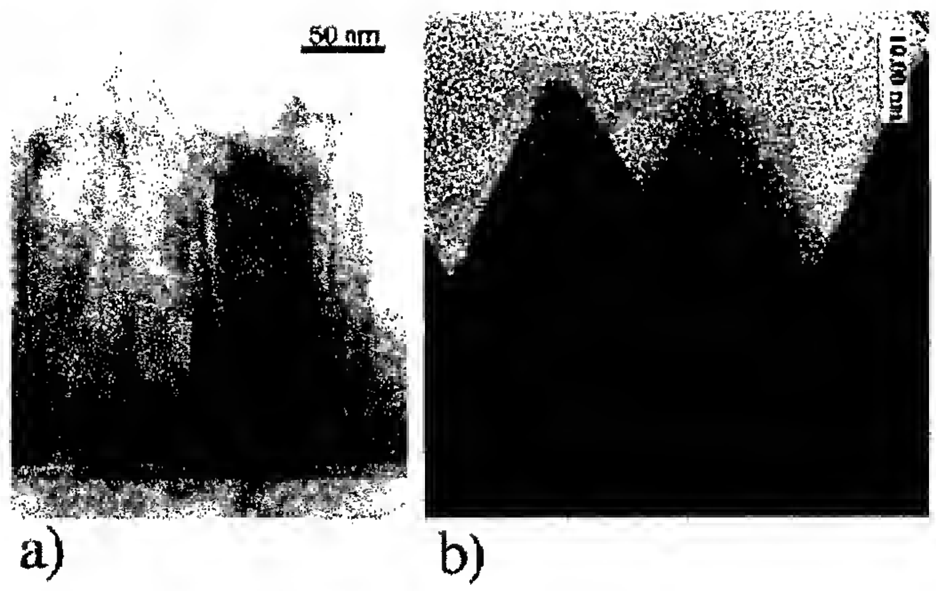

Figure 4. (*a*) Cross-sectional TEM multibeam image of a KOH-etched sample (30 min, [KOH] = 7.1 M at 40 °C). Note that the pyramidal nanostructures are not associated with structural defects. (*b*) High-resolution cross-sectional TEM image of the same sample.

Figure 5

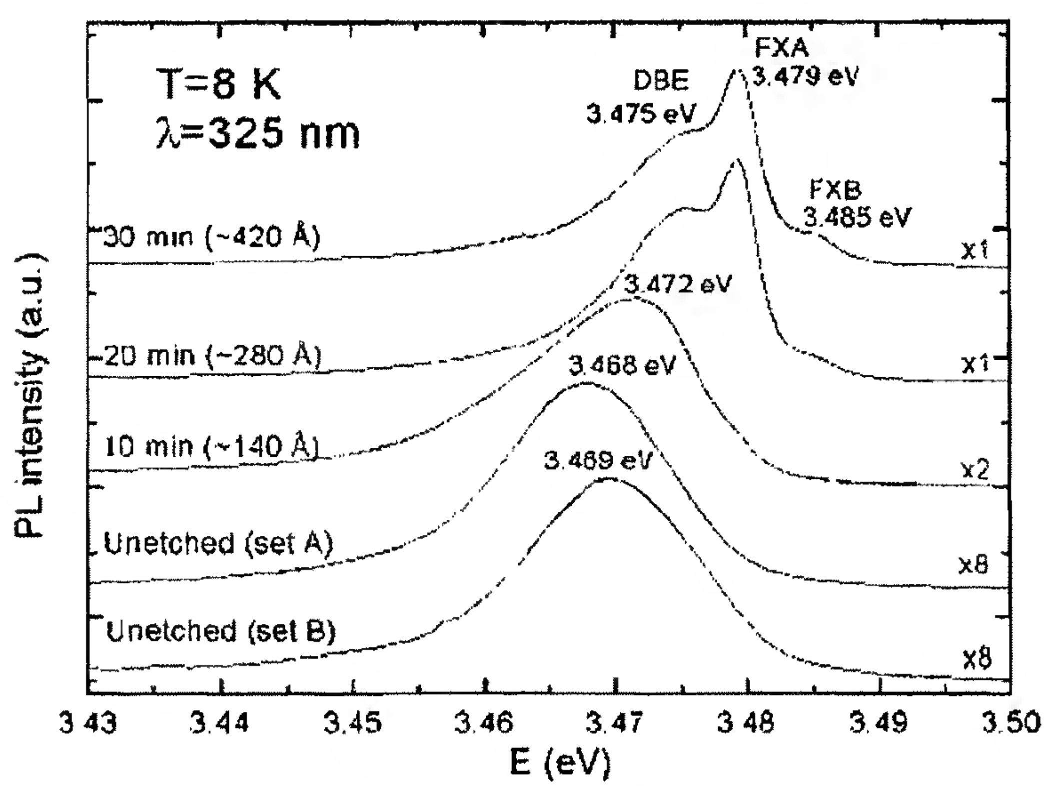

Figure 5. Low-temperature PL spectra of unetched thin AlN-buffered GaN and GaN etched in KOH: 7 M at 40 °C for 10, 20 and 30 min. The spectra of an unetched thick AlN-buffered GaN (type B) is also shown for comparison.

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Figure 4(a) presents a cross-sectional TEM multi-beam image of an etched sample (30 min in a 7.1 M KOH aqueous solution at 40 ° C). As a consequence of the etching, triangular features covering the surface of the films are generated, although no preferential etch along columnar defects or associated with surface undulations is obtained. Figure 4(b) shows a high-resolution cross-sectional TEM image of the etched sample. The angle between the basal plane (parallel to the substrate) and the surface features in the etched samples is close to 60° , indicating that these features are pyramids limited by {11-21} planes, as confirmed by selected area diffraction patterns. The pyramids are monocrystalline and they all show the same orientation relationship with the crystal structure. In agreement with previous observations [8], {11-21} planes are therefore more resistant than {10-1n} planes to the etching.

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Figure 5 shows the spectra of unetched samples (both A and B type), and three A-type samples etched at 40°C and 7.1 M for 10, 20 and 30 min (step depths of 140, 280 and 420 Å, respectively). The unetched samples present almost the same PL emission: a wide peak at ~3.468 eV, associated with the DBE excitonic transition under tensile stress conditions [15]. For increasing etching time, the PL peak in A-type samples shifts to higher energy, and two high energy transitions appear at 3.479 and 3.485 eV, which are, respectively, assigned to the FXA and FXB excitonic transitions [17]. In addition, the PL intensity is significantly enhanced with the etching time, up to a factor of 10 with times of 20 min or longer. This improvement of the optical quality of the layer is not degraded after long periods of exposure to the ambient atmosphere (several months), which eliminates that a oxide layer or dirt removal could be responsible for the enhancement of the PL intensity. The energy shift and intensity enhancement can be explained by the relaxation of tensile strain during the formation of the pyramids, although a contribution from quantum confinement in the nanostructures cannot be discarded. Also, the presence of pyramids and the characteristics of the PL may indicate spatially inhomogeneous light emission. These observations contrast with PL measurements of GaN layers after a dry etching process (either by reactive ion etching, RIE [18], or by chemical-assisted ion beam etching, CAIBE [19]), where the PL signal is degraded

5. Based on the legend in Figure 4(b), the pyramidal nanostructures shown in my publication have a size (height or depth) of about 60 nm. As shown in Figure 5, this 60 nm size results from a 30 minute etch using a step depth of 420 Å resulting in a peak high energy transition of 3.485 eV (approximately 3558 Å, which is equivalent to a wavelength of light of approximately 356 nm).

6. I further declare that all statements made herein of my own knowledge are true and all statements made on information and belief are believed to be true; and further that these

statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: 9/23/2009.

TOMAS PALACIOS